Laboratory Astrophysics using an Engineering Model XRS Microcalorimeter Array

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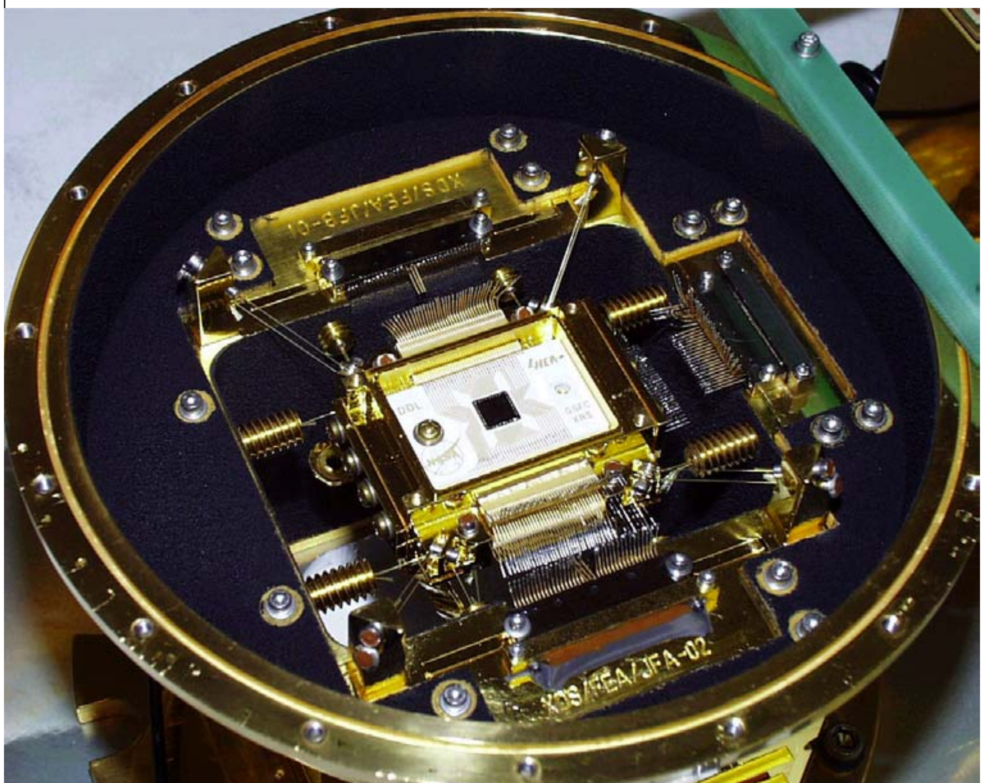
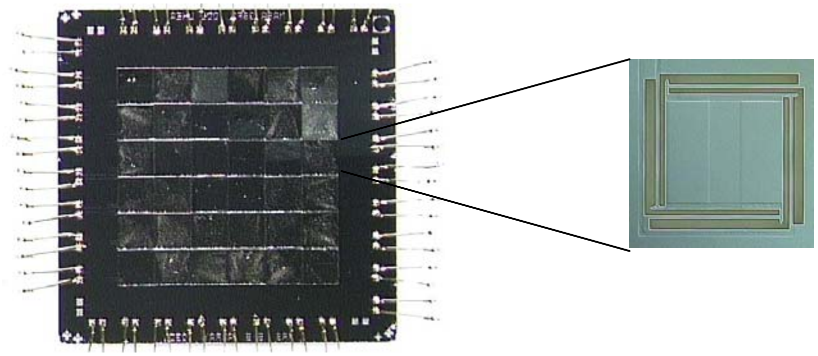
XRS Engineering Model:





Detector Characteristics:

•32 instrumented pixels, 0.64 x 0.64 mm/each

➔ 13.1 mm^2 total

•Implanted Si thermistors/FET read out

•HgTe absorbers, >95% Q.E. at 6 keV

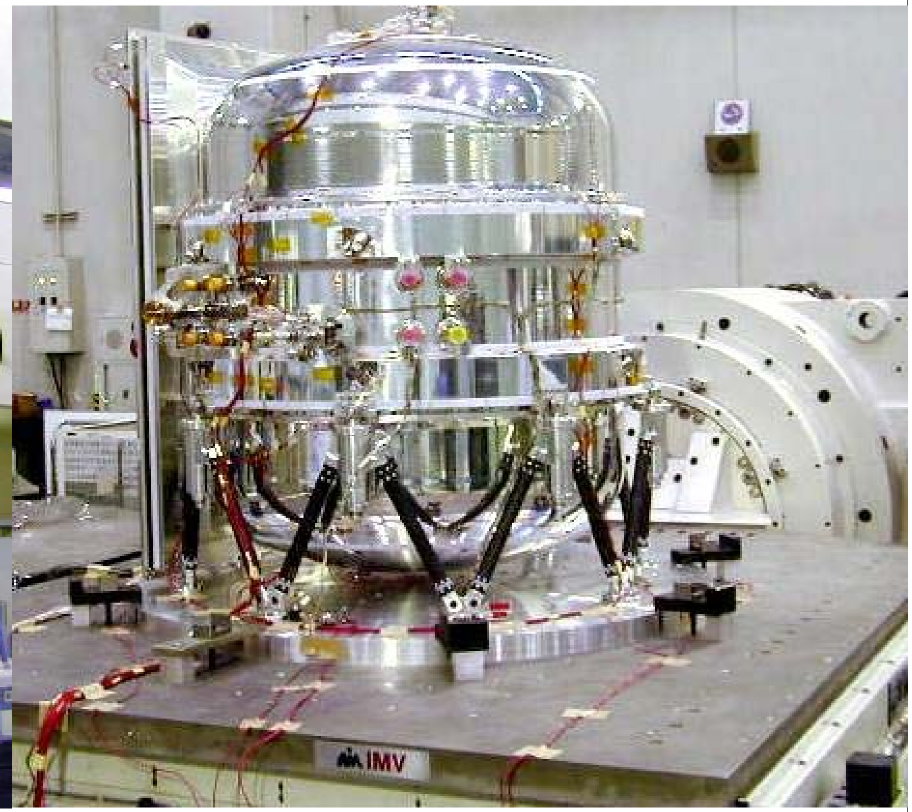
•Spectral resolution: 8-9 eV at 3.3 keV and

9-11 eV at 5.9 keV

•Operating temperature = 60 mK using an adiabatic demagnetization refrigerator

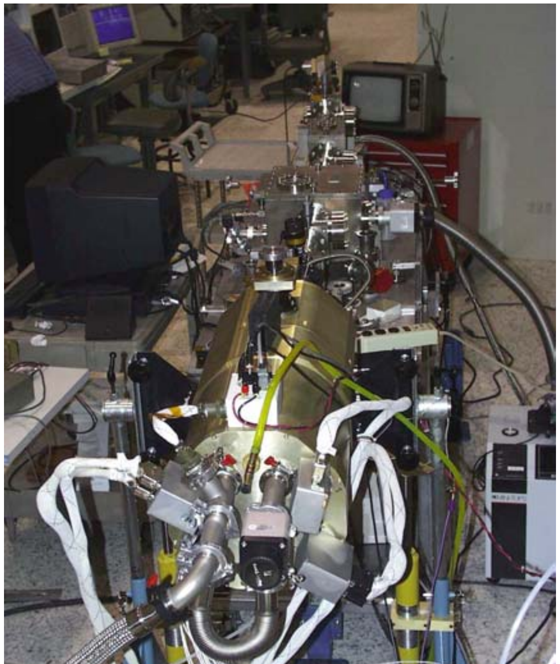
•Bandpass: 0.2 to > 12 keV

The XRS on *Astro-E*

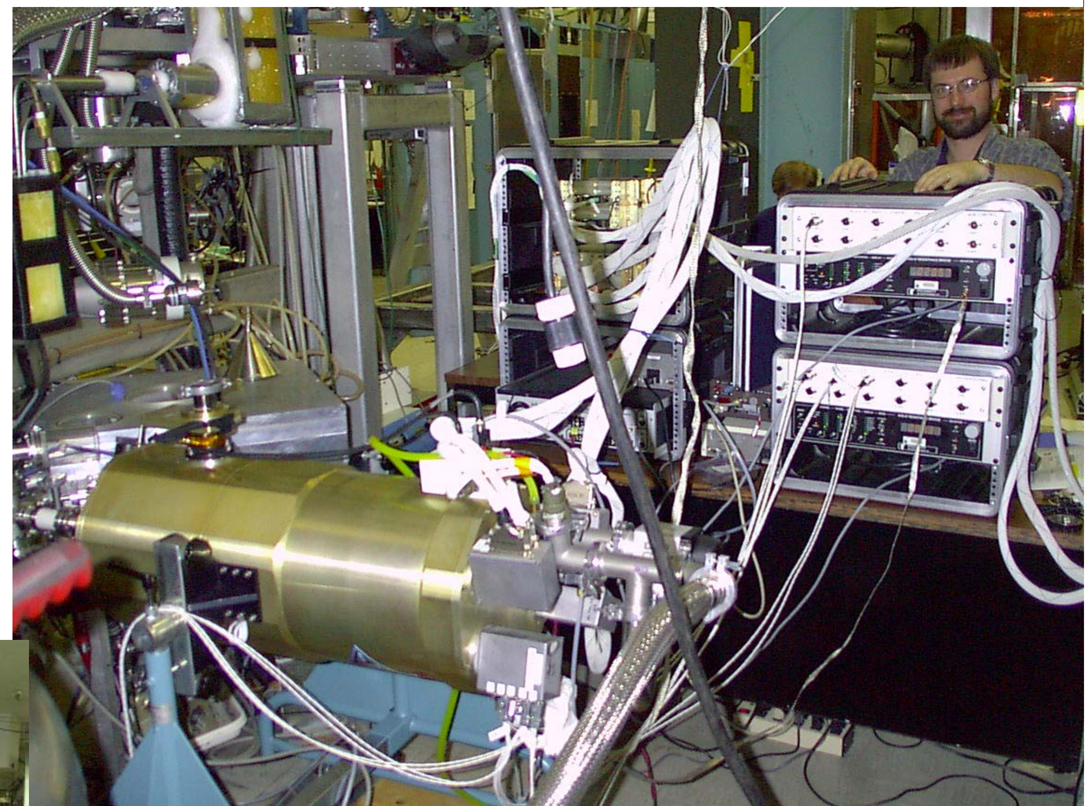


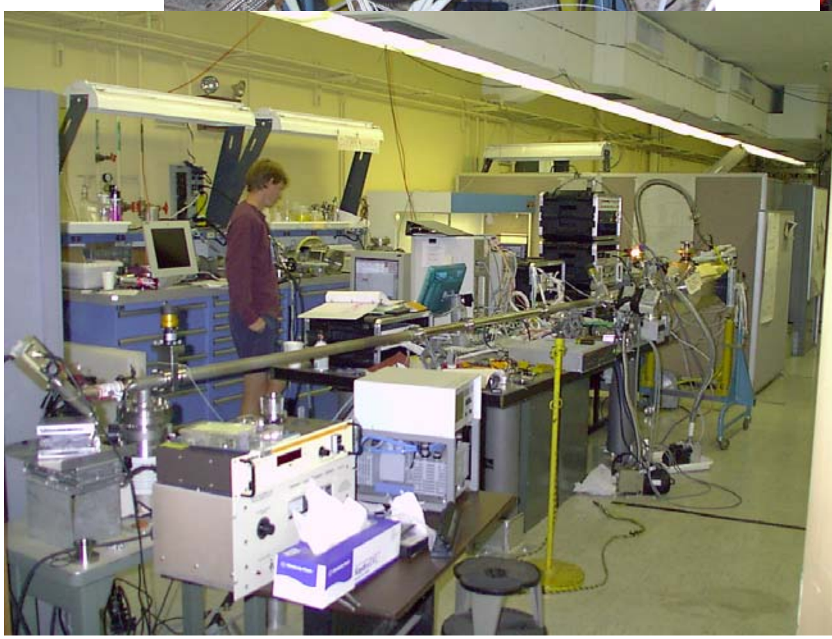
Laboratory Calorimeter Instrument

Monochrometer



EBIT

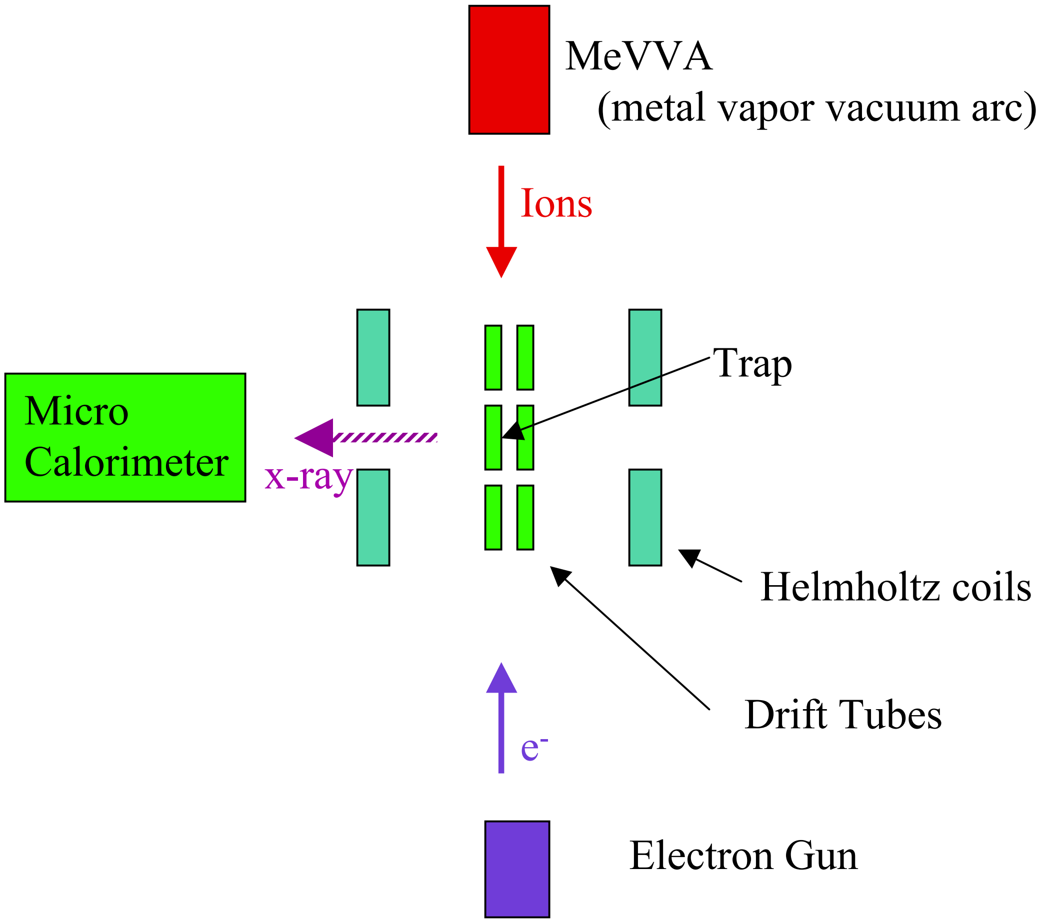




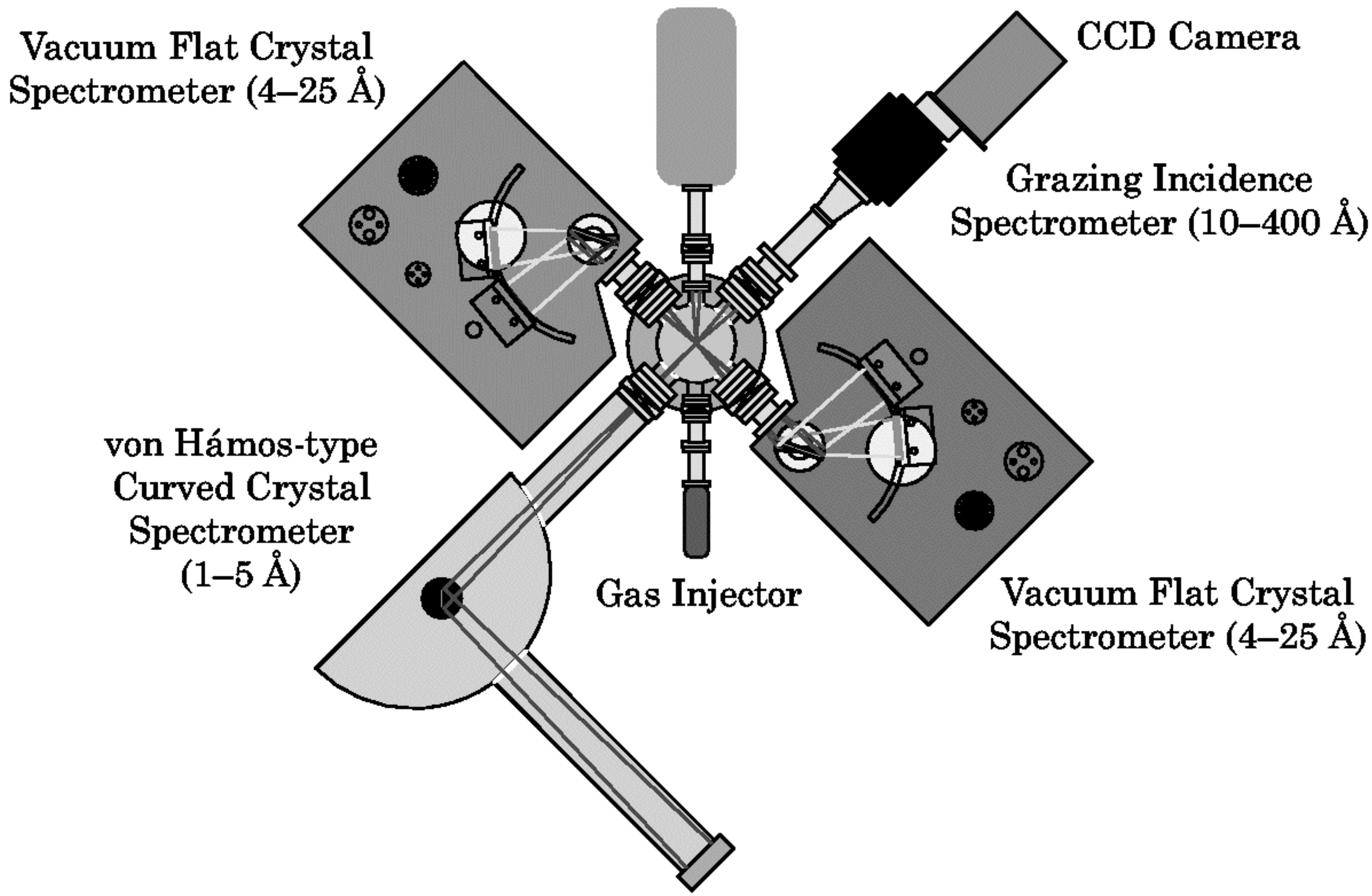
Calibration Beam Line

The EBIT machine

- Monoenergetic electron beam produces nearly pure charge states
- Fast energy sweeping gives an excellent approximation to a Maxwellian electron temperature.
- Can inject most elements using a gas injector and a metal vapor vacuum arc (MeVVA).
- Our experiments are simultaneous measurements using the microcalorimeter and usually 3 or 4 x-ray crystal spectrometers.

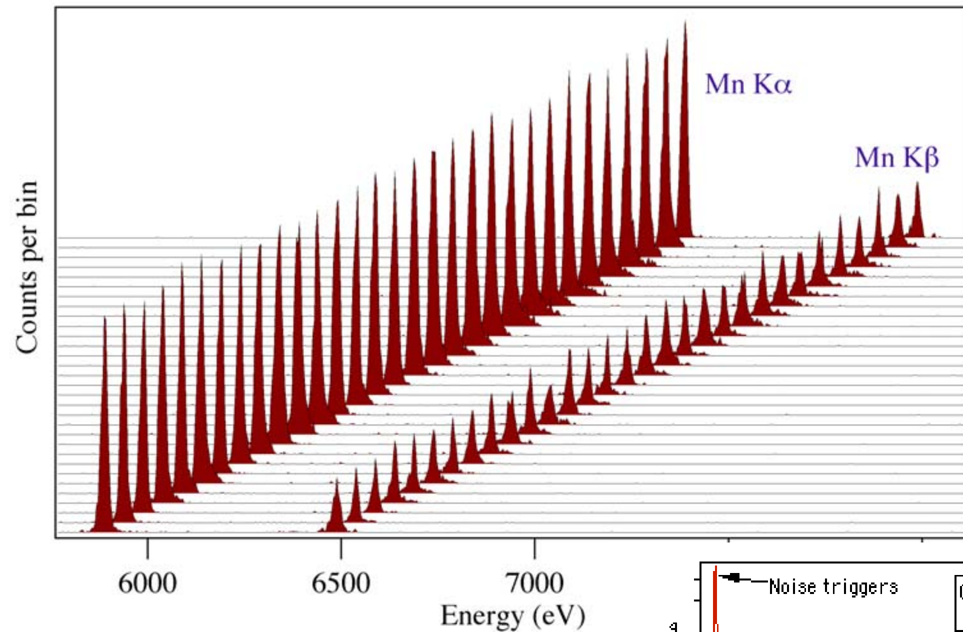


GSFC MicroCalorimeter



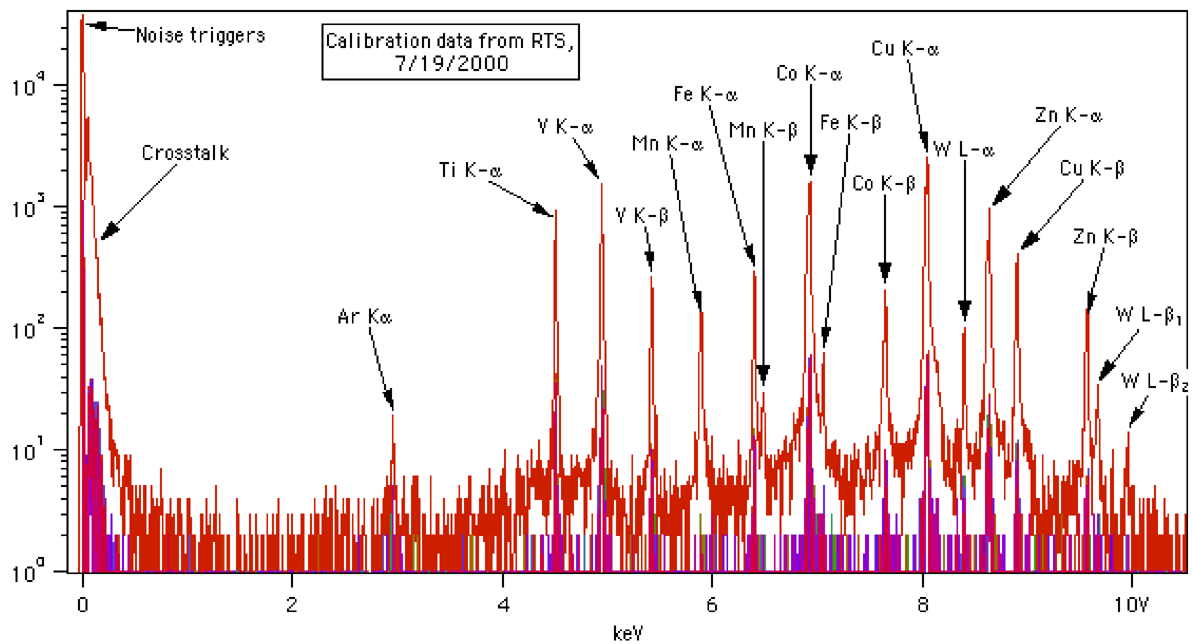
Calibration: the MOST important component

XRS calorimeters are extremely uniform:

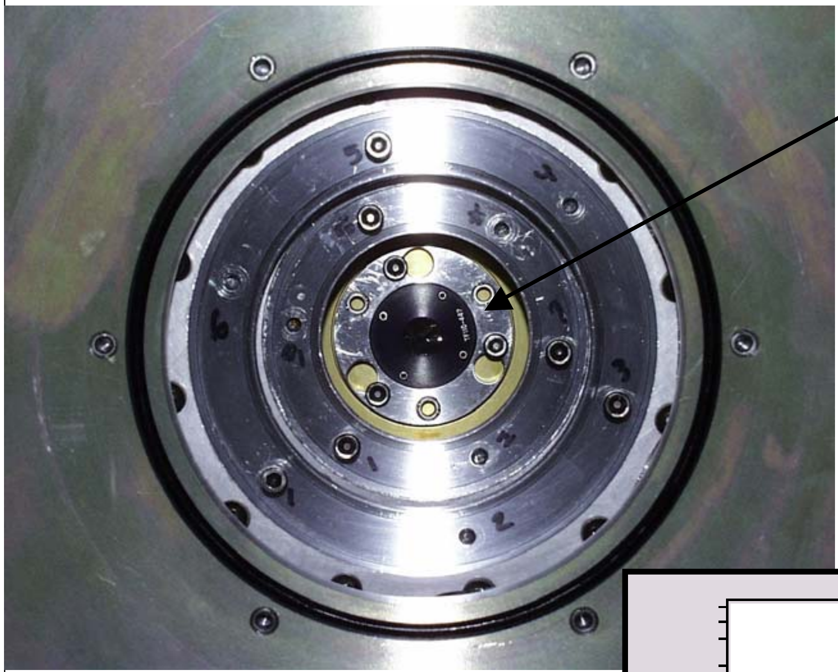


Response function:
- Spectral redistribution
- Energy scale
- Filter transmission

RTS fluorescence source:

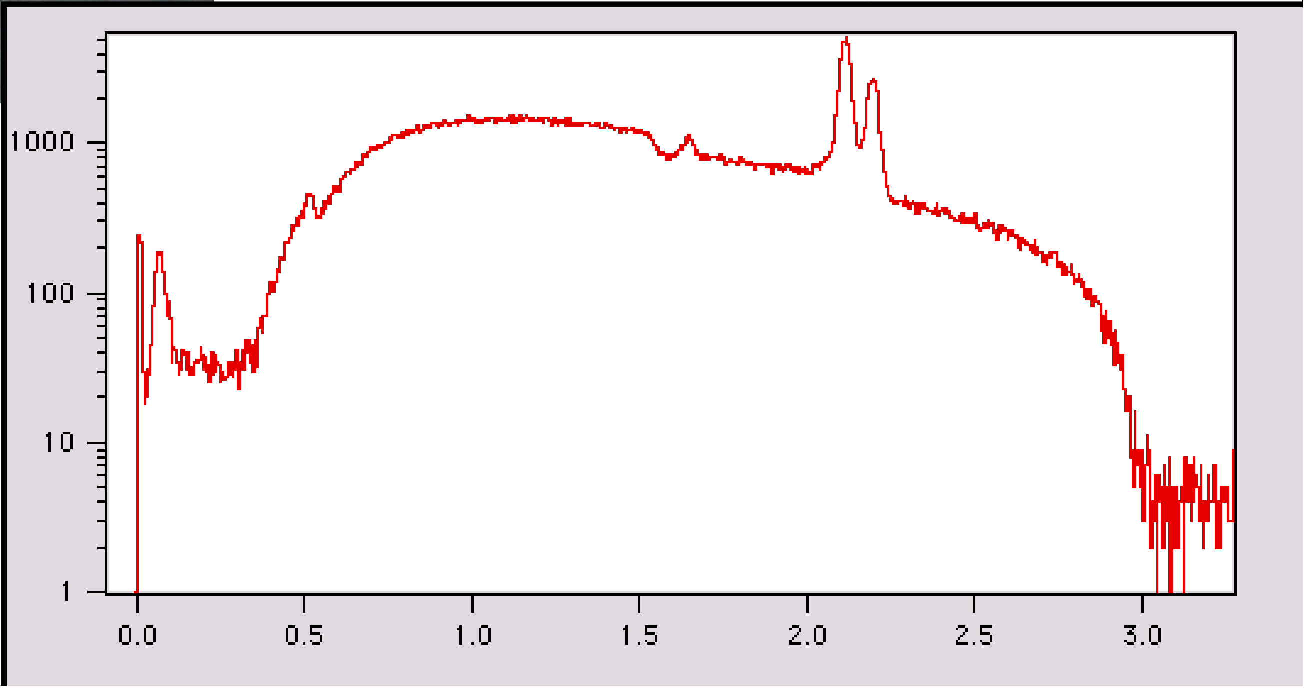


Filter Calibration:

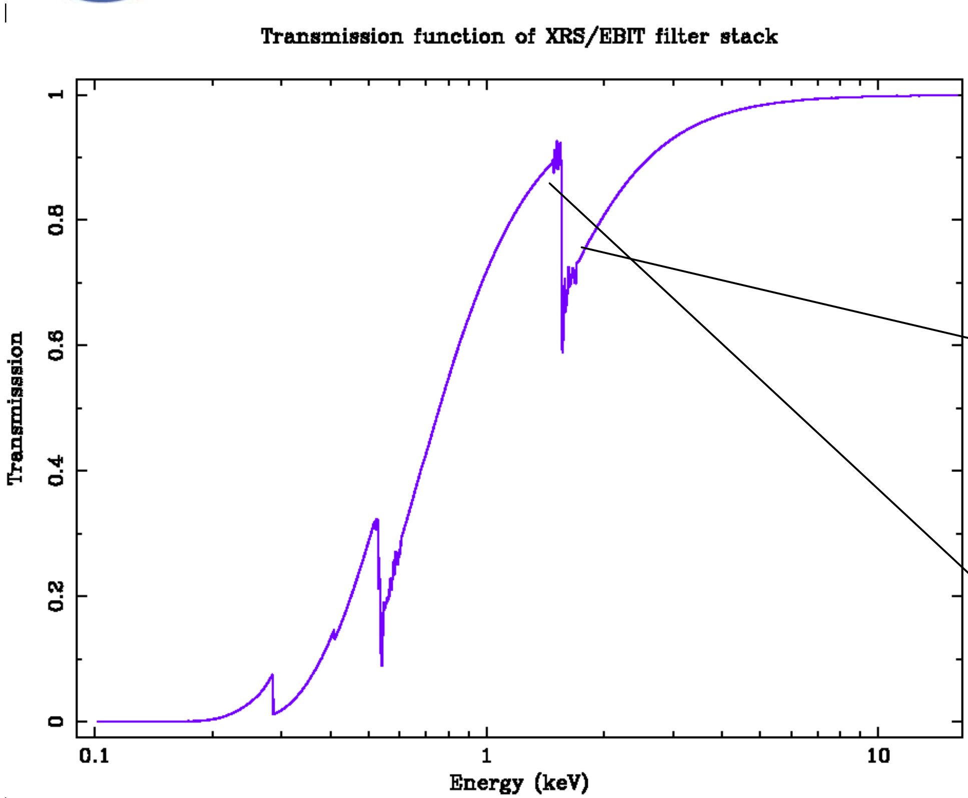


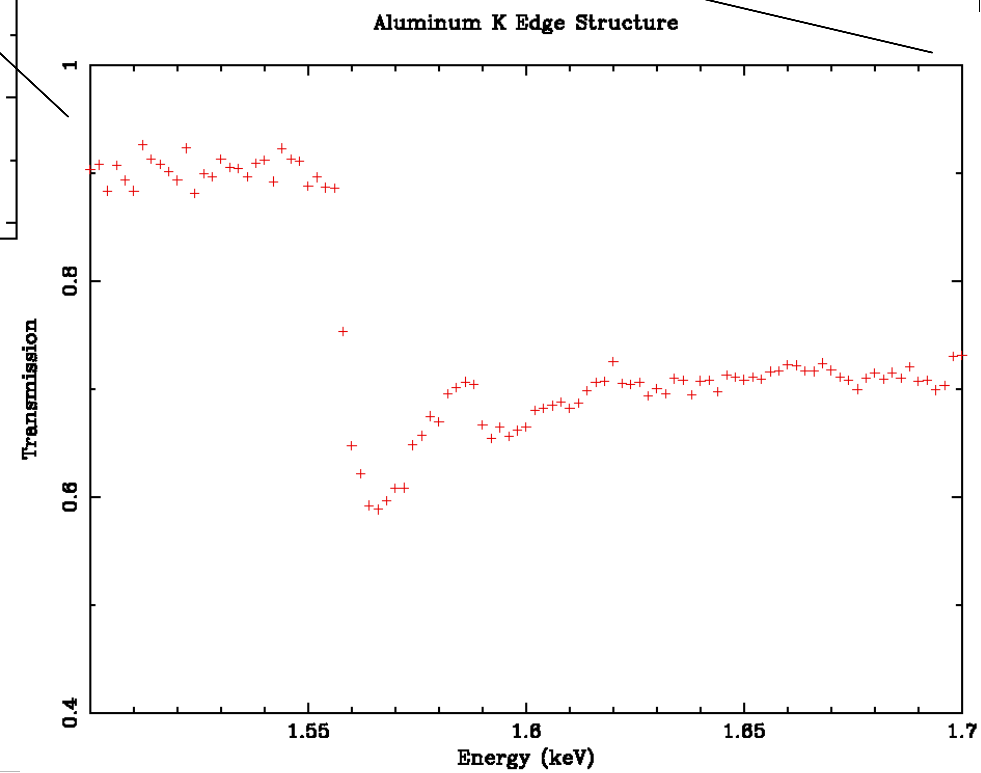
One of four aluminum on polymide infrared blocking filters (manufactured by Luxel Corporation)

TruFocus x-ray tube, Au target measure O and Al edges *in-situ:*



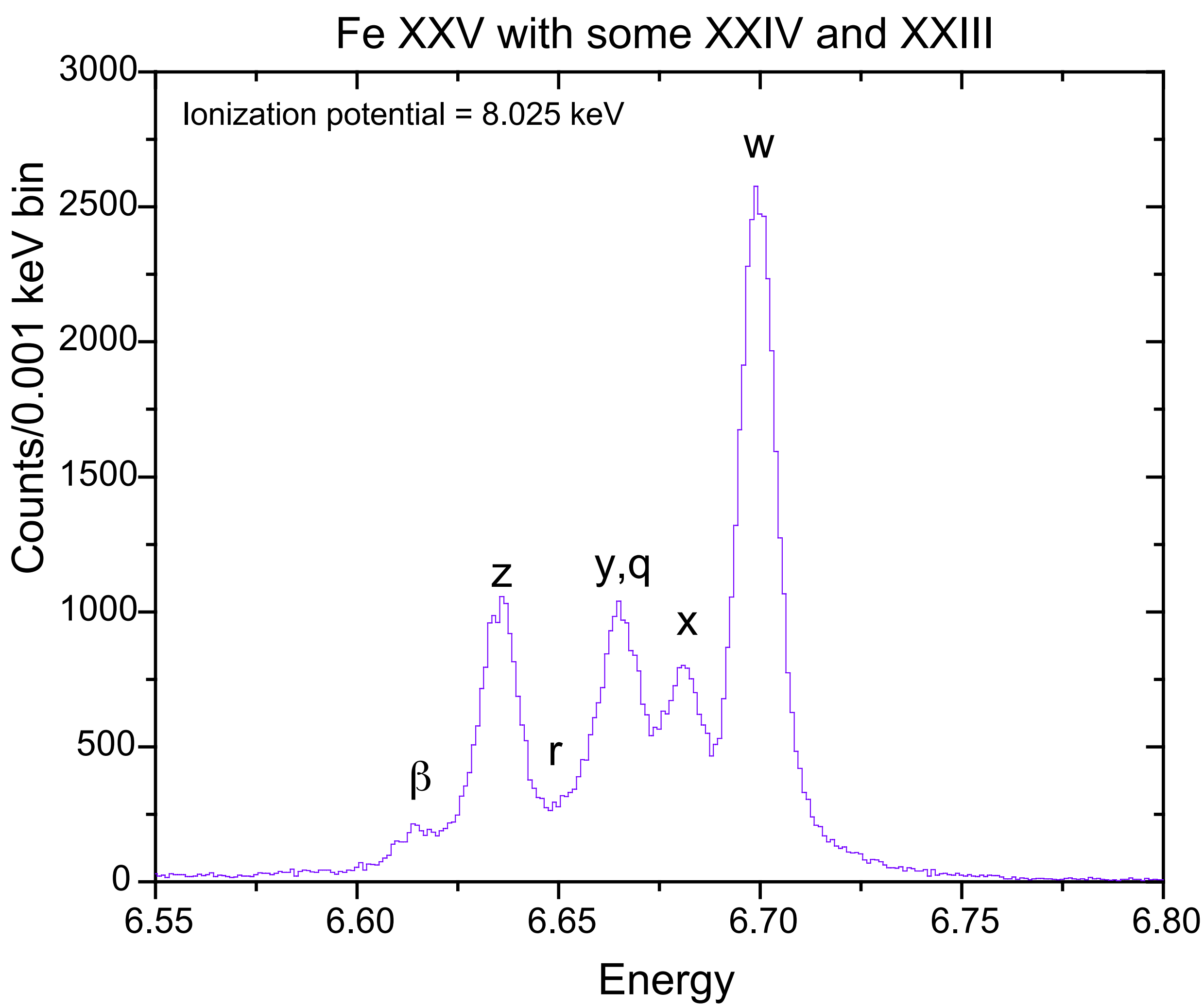
Measured filter transmission function



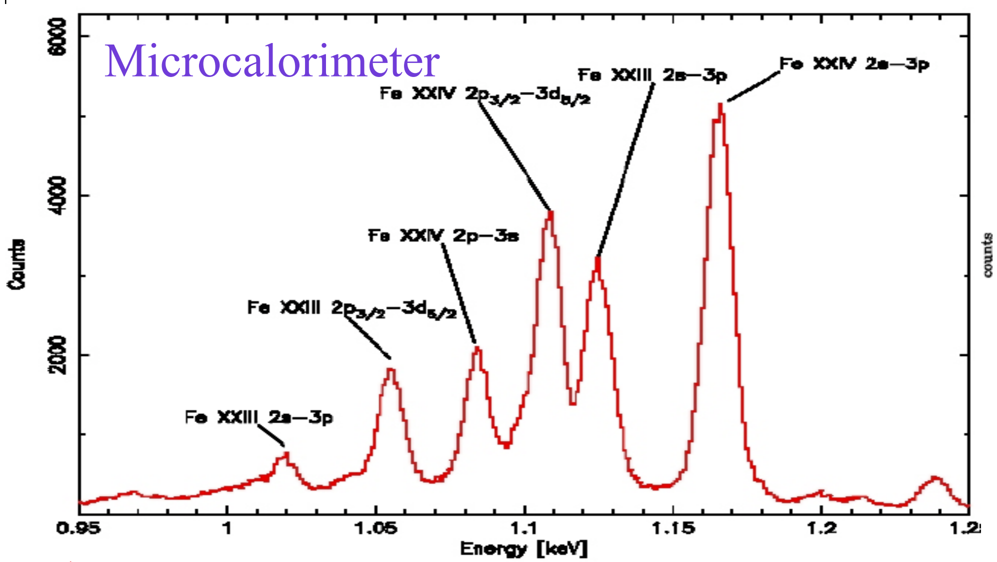


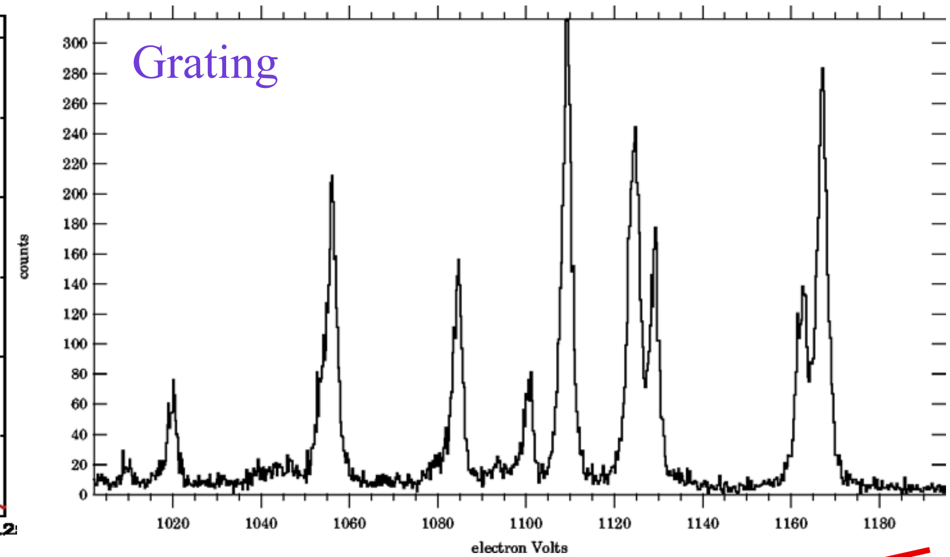
Preliminary XRS/EBIT results:

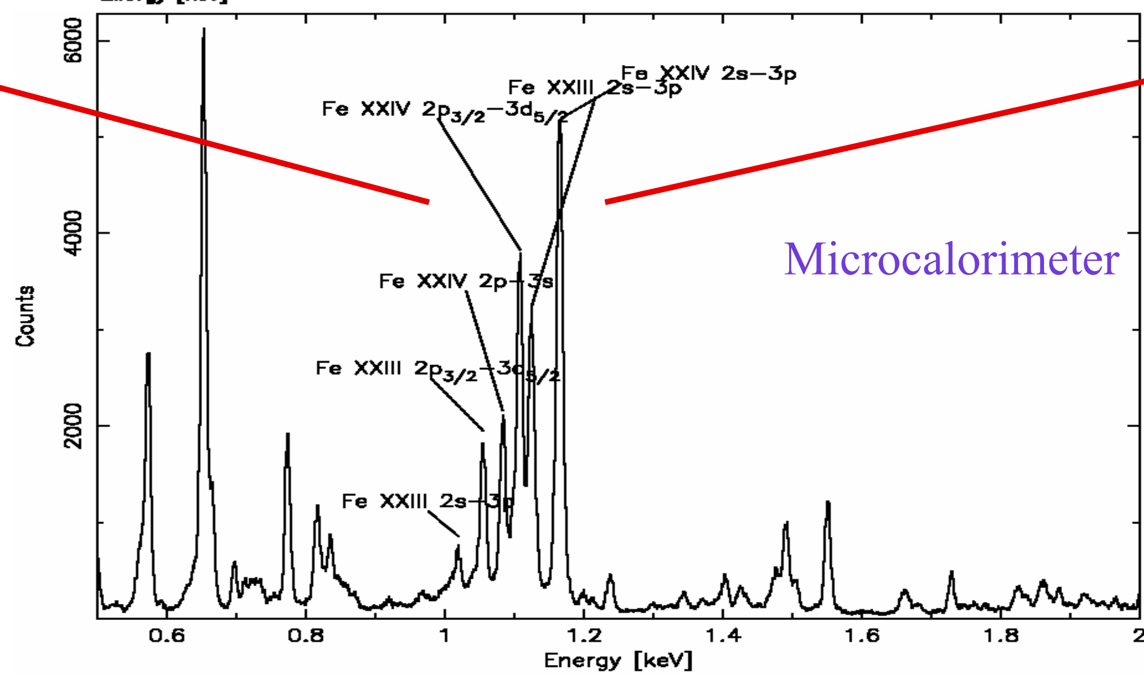
K shell emission from He-like Fe XXV:



L shell emission from Fe XXIII and XXIV:

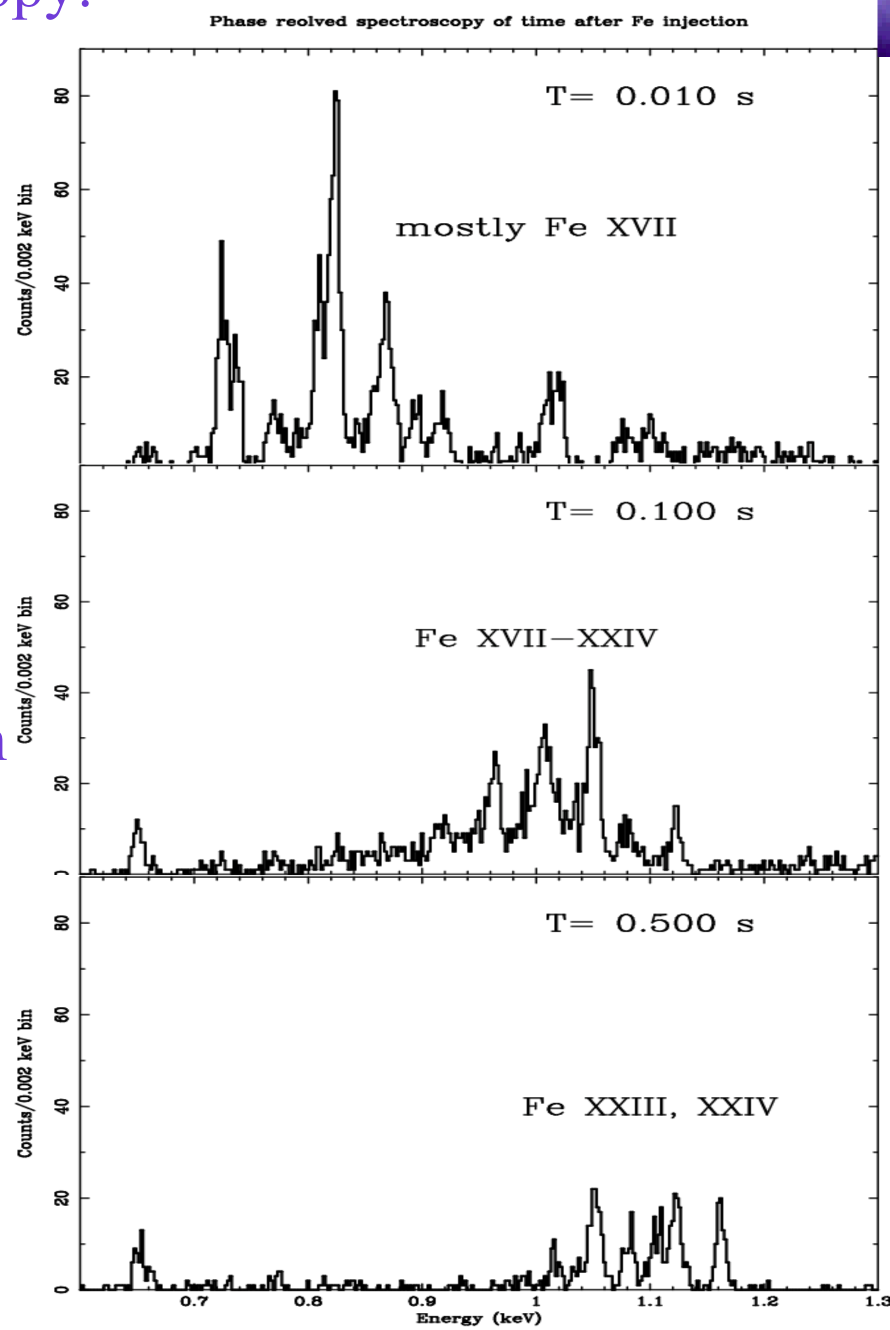




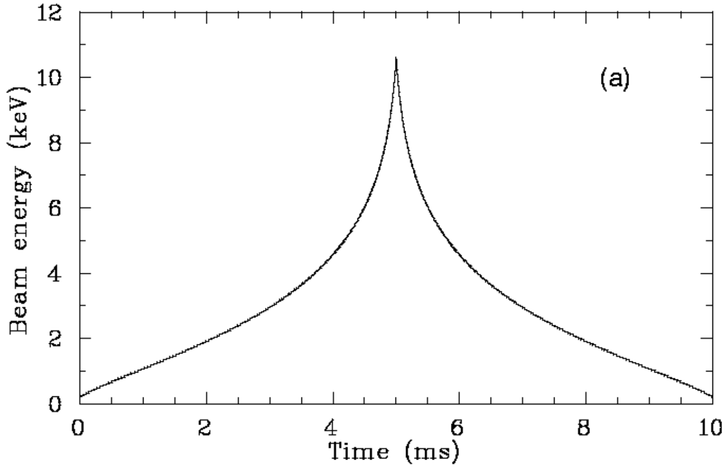


Phase resolved spectroscopy:

- The EBIT cycles from ion injection through ion trapping to ion dump every few seconds
- For Fe, the plasma is charging up for the first 0.5 seconds
- Using a GPS time sync system we phase fold the x-ray events.
- Phase folding is required to do equilibrium AND non-equilibrium plasma studies.

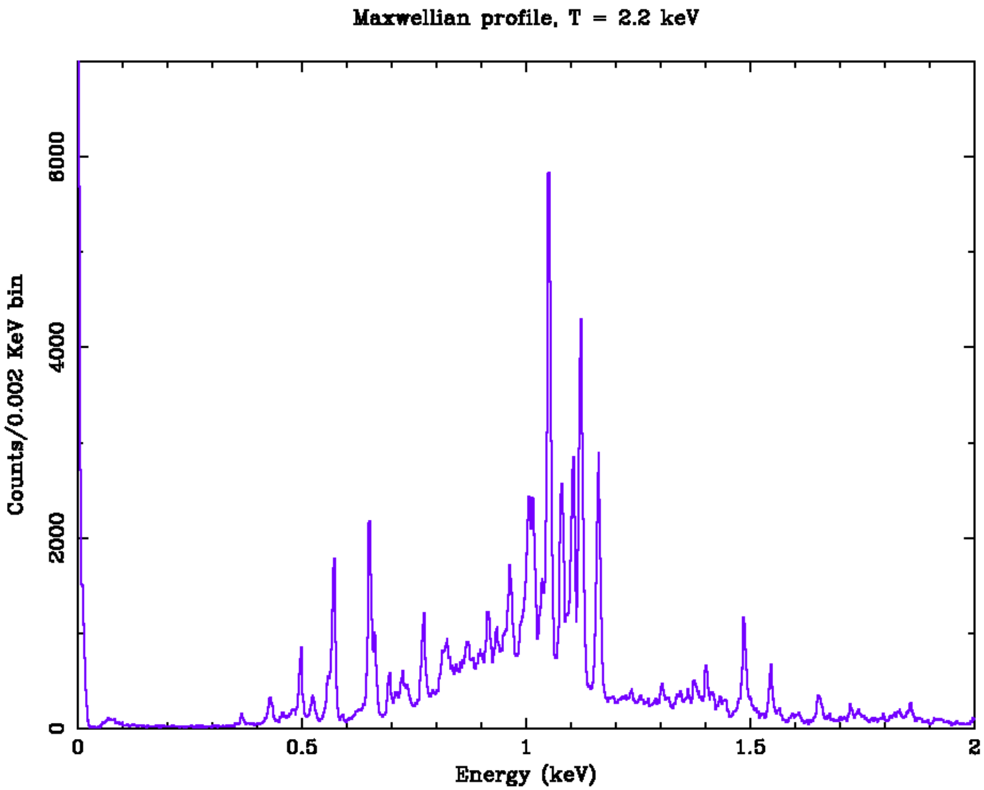


Thermal equilibrium: Maxwellian electron distributions



Maxwellian approximation with a monoenergetic electron beam

Microcalorimeter spectrum of a Maxwellian plasma, <kT> = 2.2 keV. Note Fe XVII-XXIV L shell emission.



Conclusions:

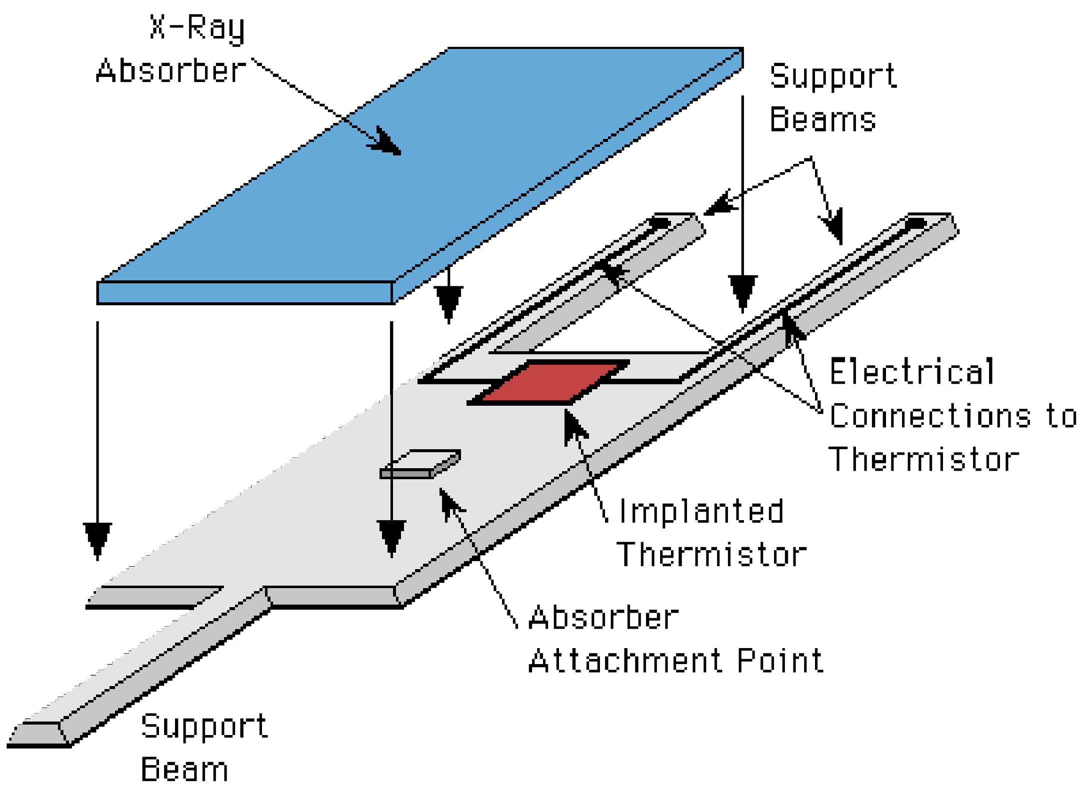
- We have successfully constructed a portable laboratory instrument using XRS engineering model components.

- We have successfully attached the XRS/EBIT instrument to the EBIT machine at LLNL and been running 24/7 for more than two weeks.

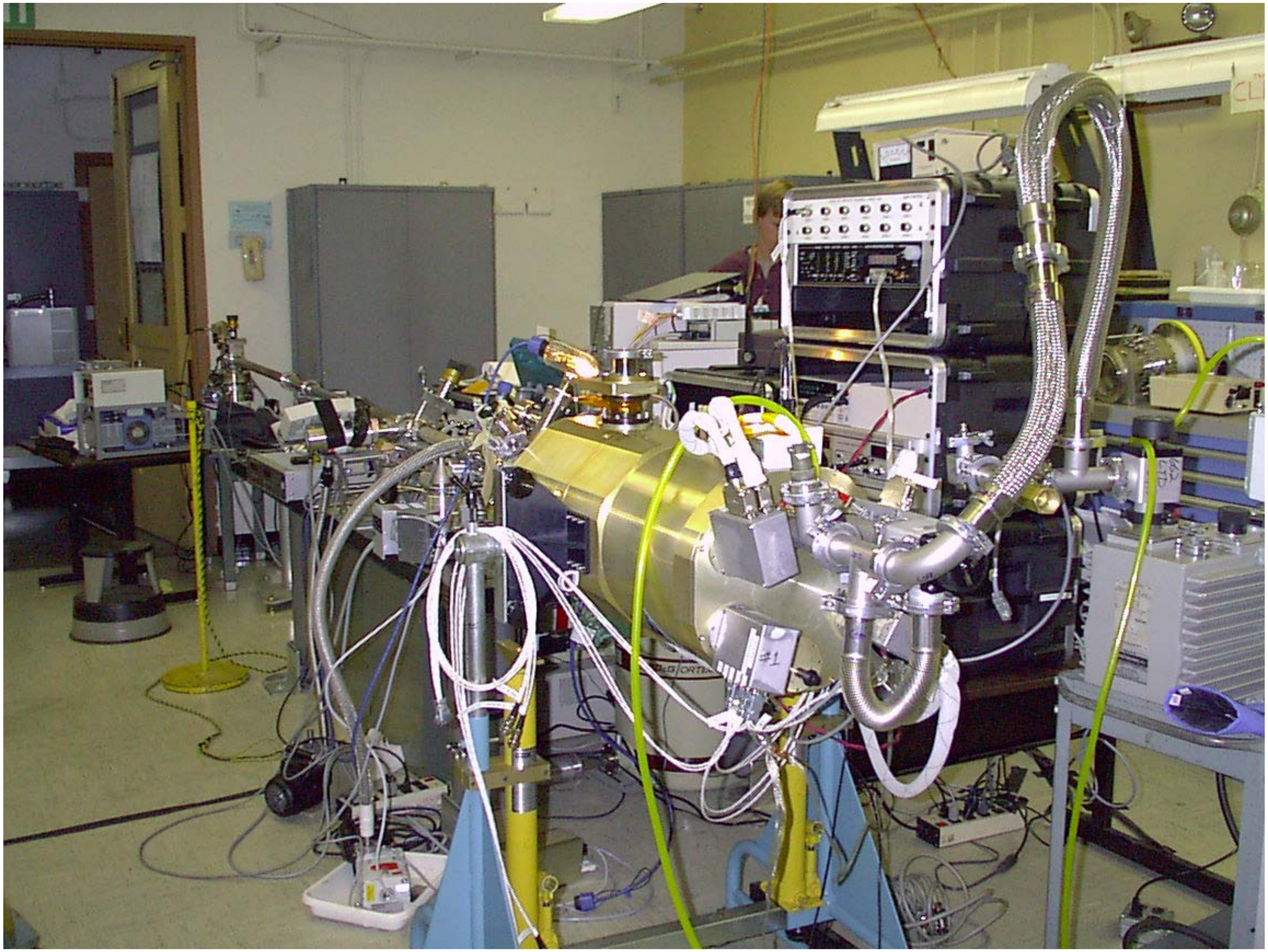
- Many, many experiments on L and K shell Fe with both monoenergetic and Maxwellian electron distributions.

- Phase resolved spectroscopy of non-equilibrium plasmas.

- We continue to run over the next few weeks to months in this observation cycle.



Single Bilinear pixel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